ROUTINE VENTILATION SURVEYING IN SOUTH WALES ANTHRACITE MINES

BY CLOYD M. SMITH

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by

Cloyd M. Smith[2]

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1/ Publication based on notes and material obtained by John W. Buch, supervising engineer, Anthracite Mechanical Mining Section, U. S. Bureau of Mines, Schuylkill Haven, Pa., during an inspection of British mines in 1945 in connection with the Solid Fuels Mission to the European Theater of Operations organized by the Technical Industrial Intelligence Committee of the Joint Chiefs of Staff.

2/ Consulting engineer, Anthracite Mechanical Mining Section, U. S. Bureau of Mines, Schuylkill Haven, Pa.

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INTRODUCTION

Progressive mine management is placing increased emphasis on improved ventilation as a contribution to better safety, health, and productivity of miners. Management is on the alert for means of bettering the working environment by increasing the flow of air and distributing it more effectively to the working places, having in mind the necessity of avoiding exorbitant ventilation costs. A basic need in planning betterments of this kind is knowledge of existing rates of flow and air pressures, information that is supplied through ventilation surveys.

Some companies make partial surveys from time to time, but few make complete surveys on a routine basis. This report describes the practice of a large British anthracite-mining company, which operates 24 collieries in South Wales, in carrying out a routine program of ventilation surveying. Ventilation characteristics and climatic conditions in the working places of its collieries are determined at frequent intervals with a view to increasing the effectiveness of ventilation and protecting the health of workers. It is thought that many of the points of the procedure used in making the surveys and in compiling and reporting the results will be applicable to American practice and that a discussion of the program may be helpful to colliery managers who are planning similar work.

ACKNOWLEDGMENT

The author acknowledges his indebteness to Amalgamated Collieries, Ltd., South Wales, for making available the information on which this paper is based, as well as for the helpful cooperation of Dr. C. G. Warner, Director of Research, in answering questions relating to surveying methods established for his company and in reviewing this manuscript.

PRACTICE OF A BRITISH COMPANY

The British anthracite-mining company in question employs about 11,500 men, 9,000 of whom work underground. Its mines are deep, and many are characterized by long, irregular passages. Effective temperatures in working places range from the high 50's to the low 70's ($^{\circ}$F). Prime objects of the program of ventilation surveying are to indicate need and means of better coursing of the air through mine passages and to improve conditions as related to the atmosphere in which the men work. Surveys are made by men who are qualified in industrial hygiene and mine ventilation. The staff includes two senior mining engineers and six mining-degree men who work full time under a committee of company executives.

The engineers divide their time almost equally between field and office tasks. It takes about a week to make a combined ventilation and environmental survey of a colliery, 10 of the company's 24 mines being surveyed every 4 months; 14 every 6 months. This report deals primarily with the ventilation surveys.

Ventilation Surveys

Measurement of rates of flow and pressure losses in mine passages and complementary determination of environmental conditions in the working places constitute two principal phases of the surveys. For the first phase, various circuits are selected, each of which traces the flow of a major current from

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its source to its terminus or sink. Typical sources are the bottom of a downcast shaft and a point of splitting one current into two or more currents. Typical sinks include the confluence of two or more splits and the bottom of an upcast shaft. A circuit is surveyed by establishing a series of measuring stations at intervals not to exceed 300 feet along its passages and by determining the cross-sectional area and the ventilation characteristics at each section. The principal ventilation characteristics that are measured at each section are rate of air flow, or quantity in cubic feet per minute, and air pressure as a differential in inches of water from an arbitrary datum.

Methods of Measurement

The rate of flow is measured by traversing the cross section with a rotating vane anemometer to determine average velocity as a step toward computing the quantity in cubic feet per minute. Water gage is determined with reference to a chosen datum by making differential pressure measurements along the passages from station to station, using flexible hollow tubing for pressure transmission and inclined U-tube manometers for pressure readings. Pressure differences may be indicated directly in inches of water or converted to inches of water by calculation, according to the type of gage used. Successive pressure drops are cumulated to give the total difference above or below datum for successive points.

Pressure Datum

The ventilating fans are operated exhausting, so the pressure is less than atmospheric throughout the mines. Although atmospheric pressure would be a desirable datum, the pressure at the bottom of a downcast shaft is frequently chosen in preference to atmospheric datum to obviate measuring the loss of pressure in the downcast shaft, a difficult and costly task. As a consequence, the calculated pressures at individual sections are not numerically related to atmospheric pressure. Rather, they differ from atmospheric by the undetermined pressure loss in the shaft.

When referred to a single datum, the pressure drops of a survey give an interrelated pattern of pressure throughout the ventilation system between the bottom of the downcast shaft and the bottom of the upcast shaft. It would be desirable to include shaft resistances and fan performance, thereby completing the survey of the ventilation cycle from the atmospheric source of the intake air to its return to the atmosphere beyond the fan outlet, but the difficulty of surveying the ventilation characteristics of the shafts is so great as to make it infeasible to include shaft work in routine surveying. Thus, the surveys represent a working compromise between the ideal of portraying the complete movement of the ventilating currents from their atmospheric source through the main passages, through the fan or fans, and back to the atmosphere, and the necessity of getting reliable data on the underground flow speedily and at reasonable cost.

Direct Pressure Measurement

Committee engineers favor direct measurement of pressure drops with tubing and inclined manometers over indirect determination with aneroid barometers, because the direct method gives more reliable results. Use of aneroid barometers is considered to require unusual skill and application of uncertain corrections for variations in atmospheric pressure, temperature, and altitude

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of the instrument. Aneroids are thought to be suitable for mapping broad outlines of the ventilation characteristics of a mine but not to be adapted to the detailed work that is needed for comprehensive surveying, a prime obstacle to their use being the necessity for determining altitude at each point of observation. This is obviated in the direct method by connecting successive points along the passages with tubing and reading the pressure drops between points.

Both methods depend for accuracy on constancy of flow within the colliery. This is an unattainable ideal, particularly when the mine is working, so each pressure reading must be observed over a period of minutes to determine its normal range, and each velocity measurement must be repeated to gage its constancy. As a survey may extend over several days, there is little remedy for variations in flow but to assume that the characteristics of each circuit were essentially uniform throughout the survey period and to be alert for abnormalities. When irregularities are found, they can usually be counteracted by waiting for return to normal flow. It is preferable to make ventilation surveys while the mine is idle, but it is not always possible to do this.

Typical Survey

Results of a routine survey will be reviewed as an example of the work the committee is doing. Nine underground air circuits were established, and 177 stations were used in making observations. The report of the survey is based upon the mine map, which is marked to show direction and rate of air flow at all points. The cumulative depression below datum is given for each measuring section, and the rate at which the pressure falls along each circuit is indicated by marking the passages with a heavy bar for each loss of 0.1 inch of water in total pressure.

Representation of Pressure Losses

Figure 1 is a portion of the ventilation map that was prepared from the survey of the mine. The heavy bars represent successive drops in pressure of 0.1 inch of water. Where the pressure drops at a moderate rate along the passage, the bars are well separated, as they are from sections 11 to 43; but where the pressure drops rapidly, the bars are close together, as from sections 46 to 47. In the former circuit, the spacing of the bars represents intervals of 1,700 to 300 feet in the mine, but in the latter circuit (46-47) it corresponds approximately with 50-foot intervals. This indicates that the resistance of the 46-47 passage to flow of air is several times as high, for equal distance as that of the 11-43 passages, but direct comparison between the resistances of two passages cannot be made from the spacing of the bars unless the passages are transmitting equal currents, because pressure drop is dependent on rate of flow as well as on the physical characteristics of the passage. Thus, assume that two passages, A and B, of equal length offer equal resistance to flow. If B were transmitting twice as much air as A, the bars on the mapped projection of B would be only a fourth as far apart as would the bars on the projection of A, because the pressure drop varies as the square of the velocity. Hence, other factors being equal, four times as many bars representing 0.1-inch pressure drop would be included in passage B as in passage A. In the case at hand, the rate of flow past section 12 (ca. 17,000 c.f.m.) is about 25 percent less than that through section 47 (22,700 c.f.m.), so the bars would be roughly 50 percent farther apart in the neighborhood of section 12 if the two passages had the

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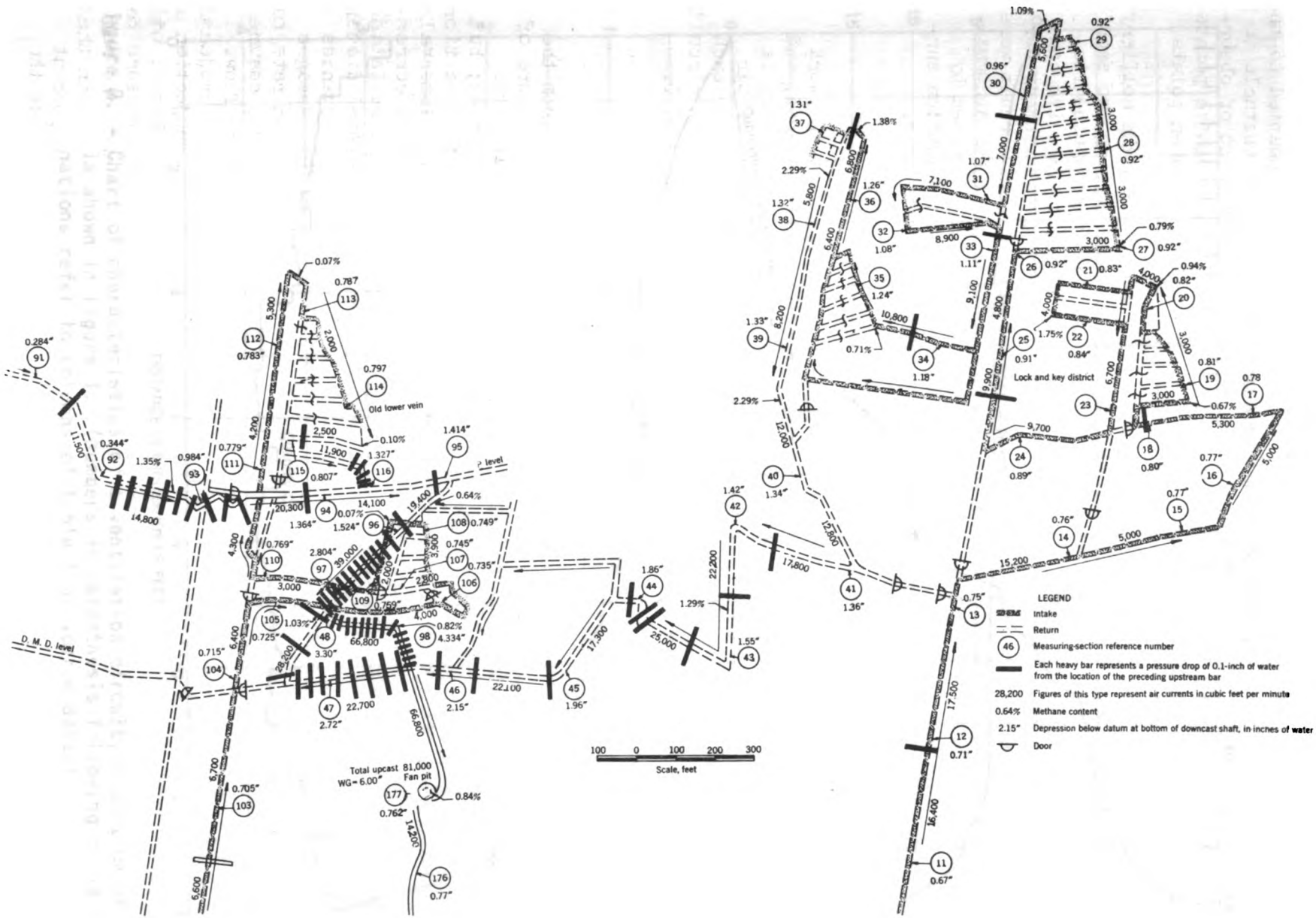
Old lower vein
Lock and key district
D. M. D. level
Total upcast 81,000
WG = 6.00"
Fan pit
Scale, feet
LEGEND
Intake
Return
Measuring-section reference number
Each heavy bar represents a pressure drop of 0.1-inch of water from the location of the preceding upstream bar
Figures of this type represent air currents in cubic feet per minute
Methane content
Depression below datum at bottom of downcast shaft, in inches of water
Door

Figure 1. - Portion of colliery ventilation survey map, showing parts of several circuits.

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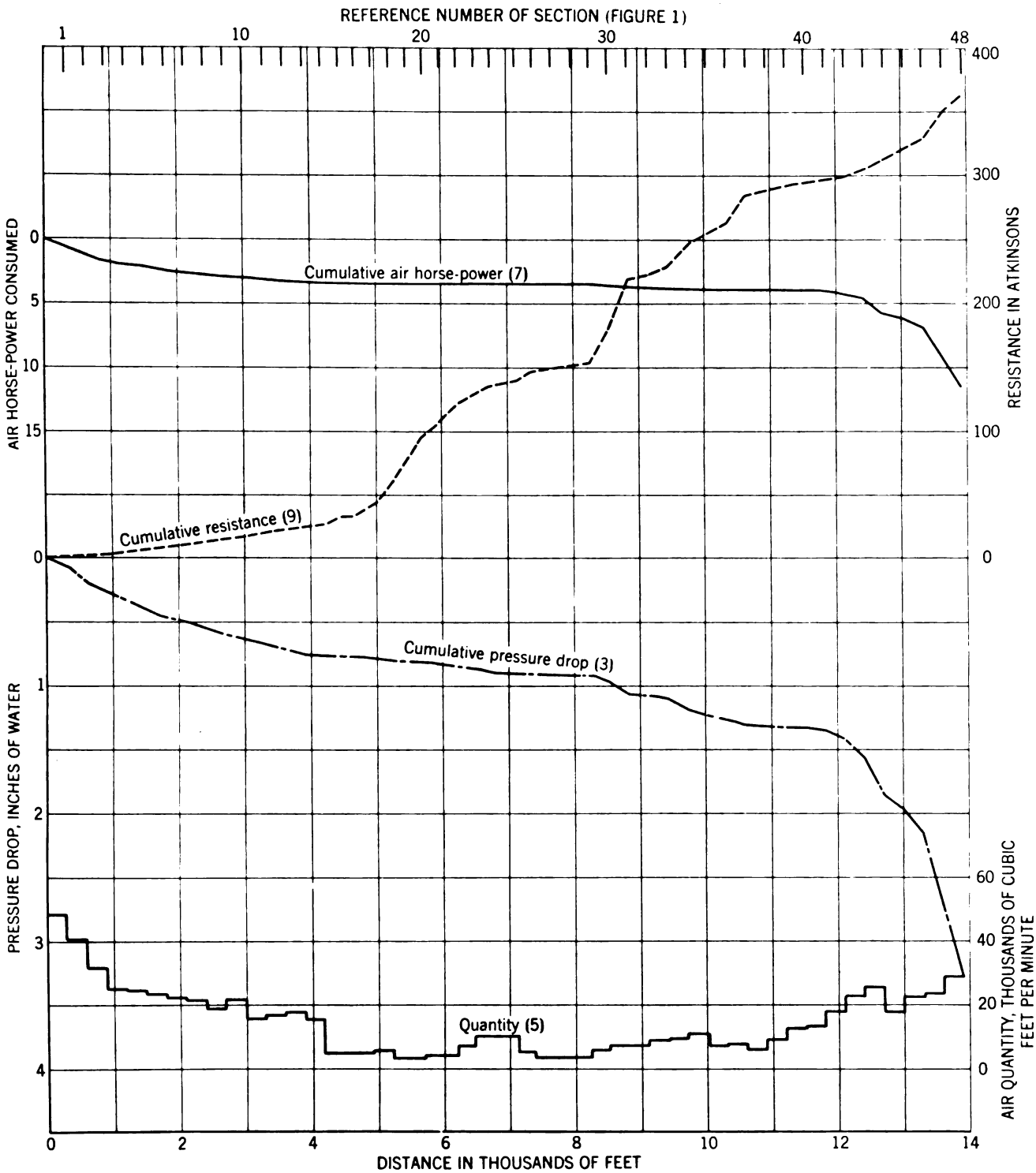

Figure 2. - Chart of characteristics of a ventilation circuit, a portion of which is shown in figure 1. (Numbers in parenthesis following curve designations refer to columns of table 1 as source data.)

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same specific resistance to air flow. However, the bars are several times as far apart near section 12 as they are near section 47, which means that the passage near section 12 is appreciably better as an air transmitter than that near section 47. This is borne out by column 13, table 1, which shows the specific resistance of the passage at 12 to be 5.0, whereas at section 47 it is 37. Thus, the bars present a graphic indication of the rate at which pressure drops along each passage, but they do not indicate comparative specific resistances of the various passages, because the rate of flow varies from passage to passage. The bars serve only to point out zones of rapid pressure drop, a condition that may arise from high rate of flow or from high resistance to flow, or both. Each such zone must be examined to determine the source of its pressure losses - whether they are dominantly from transmitting a large quantity or from bad physical conditions, such as restricted cross-sectional area and rough surfaces, which result in high resistance to a given rate of flow. For example, the worst zone of figure 1 from the standpoint of pressure drop is from sections 96 to 98, where the drop averages 0.48 inch of water per 100 feet of air travel. This is an excessively high rate of loss, but scrutiny of the map discloses that the zone is made up of two parts, one (96-97) of which transmits 39,000 cubic feet per minute and the other (97-98) 66,800 cubic feet per minute. It is evident that relief from the high resistance of both passages is needed, but that 96-97 is in worse shape as an air conductor than 97-98, because the former passage shows a comparable rate of pressure loss for a substantially lower rate of flow. This is borne out by the specific resistances of these zones - 28.2 and 11.4, respectively.

Zonal Resistances

Data for each circuit are tabulated in detail in the survey report, as shown in table 1. This table covers an air circuit known as "Lock and Key" circuit, most of which is shown on figure 1. The parts of circuits represented in this figure follows:

Circuit	Stations (inclusive numbering)	
	In circuit	In figure 1
Lock and Key.....	1-48	11-48
Main west side.....	49-98	49-98
Old lower vein.....	99-116	103-116
Between upcast shafts.....	171-177	176-177

The essential characteristics of flow from table 1, columns 3, 5, 7, and 9, are shown graphically in figure 2, which visualizes the relationships among rate of flow, cumulative pressure drop, resistance, and air horsepower as functions of location in the mine.

Table 1 shows the resistance to range up to 140.5 Atkinsons per thousand feet, whereas the better passages have resistances less than 10 Atkinsons per thousand feet. Table 1a supplements table 1 by supplying data on the ventilation characteristics of the high-resistance zone (96-98) previously referred to.

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TABLE 1. - Data of circuit A

Reference no. of section (1)	Pressure drop in in. of water (2)	Cumulative water gauge in in. (3)	Length of zone in ft. (4)	Quantity in c.f.m. (5)	A.H.P. Loss in zone (6)	Cumulative A.H.P. loss (7)	Resistance of zone in Atkinsons (8)	Cumulative resistance (9)	Resistance per 1,000 ft. (10)	A.H.P. loss per 1,000 ft. (11)	Pressure drop in in. of water per 1,000 ft. (12)	Specific resistance of zone (13)
1	0.07	0.07	300	48,200	0.531	0.531	0.56	0.56	1.8	1.77	0.23	1.0
2	0.11	0.18	300	40,200	0.696	1.227	1.27	1.83	4.2	2.32	0.37	2.2
3	0.09	0.27	300	31,900	0.452	1.679	1.66	3.49	5.5	1.51	0.30	2.9
4	0.06	0.33	300	24,900	0.235	1.914	1.81	5.30	6.0	0.78	0.20	3.2
5	0.07	0.40	300	24,300	0.268	2.182	2.22	7.52	7.4	0.89	0.23	4.0
6	0.06	0.46	300	23,300	0.220	2.402	2.07	9.59	6.9	0.73	0.20	3.7
7	0.03	0.49	300	22,100	0.104	2.506	1.15	10.74	3.8	0.35	0.10	2.0
8	0.06	0.55	300	21,200	0.200	2.706	2.50	13.24	8.3	0.67	0.20	4.4
9	0.04	0.59	300	18,200	0.115	2.821	2.27	15.51	7.6	0.38	0.13	4.1
10	0.04	0.63	300	21,500	0.135	2.956	1.62	17.13	5.4	0.45	0.13	2.9
11	0.04	0.67	300	15,500	0.098	3.054	3.12	20.25	10.4	0.33	0.13	5.6
12	0.04	0.71	300	16,400	0.103	3.157	2.79	23.04	9.3	0.34	0.13	5.0
13	0.04	0.75	300	17,500	0.110	3.267	2.46	25.50	8.2	0.37	0.13	4.4
14	0.01	0.76	285	15,200	0.024	3.291	0.81	26.31	2.8	0.08	0.04	1.5
15	0.01	0.77	255	5,000	0.008	3.299	7.50	33.81	29.4	0.31	0.04	15.7
16	0.001	0.771	255	5,000	0.001	3.300	0.75	34.56	2.9	0.004	0.004	1.6
17	0.01	0.78	255	5,000	0.008	3.308	7.50	42.06	29.4	0.31	0.04	15.7
18	0.02	0.80	255	5,300	0.017	3.325	13.35	55.41	52.3	0.67	0.08	28.0
19	0.01	0.81	255	3,000	0.005	3.330	20.80	76.21	81.6	0.02	0.04	44.0
20	0.01	0.82	255	3,000	0.005	3.335	20.80	97.01	81.6	0.02	0.04	44.0
21	0.01	0.83	255	4,000	0.006	3.341	11.70	108.71	45.9	0.06	0.04	25.0
22	0.01	0.84	255	4,000	0.006	3.347	11.70	120.41	45.9	0.06	0.04	25.0
23	0.02	0.86	255	6,700	0.021	3.368	8.36	128.77	32.8	0.08	0.08	18.0
24	0.03	0.89	255	9,700	0.046	3.414	5.98	134.75	23.5	0.18	0.12	12.6
25	0.02	0.91	375	9,900	0.031	3.445	3.83	138.58	10.2	0.08	0.05	5.5
26	0.01	0.92	285	4,800	0.076	3.521	8.12	146.70	28.5	0.03	0.04	15.0
27	0.001	0.922	285	3,000	nil	3.471	2.08	148.78	7.3	nil	0.004	3.9
28	0.001	0.923	285	3,000	nil	3.471	2.08	150.86	7.3	nil	0.004	3.9
29	0.001	0.924	285	3,000	nil	3.471	2.08	152.94	7.3	nil	0.004	3.9
30	0.04	0.964	285	5,600	0.035	3.556	23.80	176.74	83.6	0.12	0.14	45.0
31	0.11	1.074	300	7,000	0.121	3.677	42.15	218.89	140.5	0.40	0.37	75.0
32	0.01	1.084	300	7,100	0.011	3.688	3.72	222.61	12.4	0.04	0.03	66.0
33	0.03	1.114	300	8,900	0.042	3.730	7.11	229.72	23.7	0.14	0.10	12.7
34	0.07	1.184	300	9,100	0.100	3.830	15.83	245.55	52.7	0.33	0.23	28.0
35	0.06	1.244	300	10,800	0.102	3.932	9.64	255.19	32.1	0.34	0.20	17.0
36	0.02	1.264	300	6,400	0.020	3.952	9.15	264.34	30.5	0.07	0.07	16.0
37	0.05	1.314	300	6,800	0.054	4.006	20.25	284.59	67.7	0.18	0.17	36.0
38	0.01	1.324	300	5,800	0.009	4.015	5.56	290.15	18.5	0.03	0.03	9.9
39	0.01	1.334	300	8,200	0.013	4.028	2.79	292.94	9.3	0.04	0.03	5.0
40	0.01	1.344	300	12,000	0.019	4.047	1.30	294.24	4.3	0.06	0.03	2.3
41	0.02	1.364	300	12,800	0.040	4.087	2.87	297.11	9.6	0.13	0.07	5.1
42	0.06	1.424	300	17,800	0.168	4.255	3.56	300.67	11.9	0.56	0.20	6.4
43	0.13	1.554	300	22,200	0.455	4.710	4.94	305.61	16.3	1.52	0.43	8.7
44	0.31	1.864	300	25,000	1.220	5.930	9.31	314.92	31.0	4.07	1.04	16.6
45	0.11	1.974	300	17,300	0.300	6.230	6.89	321.81	23.0	1.00	0.37	12.3
46	0.18	2.154	300	22,100	0.627	6.857	6.93	328.74	23.0	2.09	0.60	12.3
47	0.57	2.724	300	22,700	2.038	8.895	20.75	349.49	69.0	6.79	1.90	37.0
48	0.58	3.304	300	28,200	2.576	11.471	13.65	363.14	45.3	8.58	1.93	24.0

Column explanations

(1) Air measuring sections are numbered serially, going downstream in each circuit.

(2) Pressure drop measured from preceding section. In case of section 1 it was measured from bottom of downcast shaft.

(3) 1/ Cumulative pressure drops from section to section. This column gives the water-gauge depression from the origin of the circuit to the reference section.

(4) The distance between the preceding section and the reference section; a zone.

(5) 1/ Rate of flow as determined by traversing with rotating vane anemometer.

(6) $= \frac{5.2 \times \text{Col. } 2 \times \text{Col. } 5}{33{,}000}$, loss in air horsepower.

(7) 1/ Cumulative power loss from beginning of circuit, in air horsepower.

(8) $= 5.2 \times \text{Col. } 2 \ \frac{(60{,}000)^2}{(\text{Col. } 5)}$

(9) 1/ Cumulative resistance of circuits in Atkinsons.

(10) $= \frac{1{,}000 \times \text{Col. } 8}{\text{Col. } 4}$ Atkinsons

(11) $= \frac{1{,}000 \times \text{Col. } 6}{\text{Col. } 4}$

(12) $= \frac{1{,}000 \times \text{Col. } 2}{\text{Col. } 4}$

(13) $= \frac{\text{Col. } 2 \times \left(\frac{100{,}000}{\text{Col. } 5}\right)^2 \times 1{,}000}{\text{Col. } 4}$

Col. 13 and column explanations supplied by author.

1/ Data charted, figure 2.

TABLE 1a. - Data of selected high resistance zones

96	0.11	1.524	180	19,400	0.336	3.597	5.49	210.30	30.5	1.87	0.61	16.3
97	1.28	2.804	300	39,000	7.862	11.459	15.78	226.08	52.7	26.23	4.27	28.2
98	1.53	4.334	300	66,800	16.100	27.559	6.45	232.53	21.3	53.67	5.10	11.4

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The Atkinson is used by British engineers to compare resistance of equal lengths of different passages at equal volumetric rates of flow, but its use is clouded by two definitions that lead to different values. The unit used by committee engineers is the resistance that will require a pressure of 1 pound per square foot (0.192 inch of water) to pass 1,000 cubic feet of air per second. The other Atkinson is based upon a rate of flow of 100,000 cubic feet of air per minute instead of 1,000 cubic feet per second. Its use leads to values 2.78 times as great as the values shown in tables 1 and 1a.

The Atkinson is not used by American engineers. In its place, resistance factor has been recommended. It is defined[3/] as the resistance, in inches of water, that a passage presents to the flow of 100,000 cubic feet per minute. The term "specific resistance" is suggested for the resistance to a flow of 100,000 cubic feet per minute per thousand feet of air travel. It is compiled in table 1, where the specific resistance ranges from 1 to 75 and averages 15. In the high-resistance zone (96-98), the range was from 11.4 to 28.2, with an average of 18.7. Specific resistance is proportional to the Atkinson.

Methane Content

Rates of flow and methane content at major stations in the circuit are reviewed in table 2, whereas the physical characteristics of the passages are covered in an additional tabulation, of which table 3 represents part of the description for circuit A.

It is interesting to note that currents are designated on the map (fig. 1) as intake currents until they have left the last productive place, although they may acquire an appreciable methane content in the early producing sections through which they pass. Under this scheme, partly contaminated air is classified as intake air. This suggests need for a third-type designation, such as intermediate air, to indicate currents that have ventilated some working places but are still fit and used for ventilating other places before they are passed into return-air passages.

Concentration of methane in return circuits is indicated on the map at points of sampling. At several stations, methane content exceeded 1 percent, and in a few cases it exceeded 2 percent, indicating approach to explosive mixtures. Danger points such as these are delineated by the survey maps and accompanying reports. The latter discuss excessive methane content, where encountered, and suggest remedies. The reports also go into the related topic of leakage of air past doors and stoppings with consequent diminution of flow through working sections. This is illustrated in the interpretive discussion of rates of flow past station 13 (fig. 1), where leakages of 7,000 and 2,000 cubic feet per minute are cited, and in treating panel 18-23, in which a methane concentration of 1.75 percent was found. The report points out that this dangerous gas condition could easily be remedied by improving the coursing of the air.

3/ McElroy, G. E., Engineering Factors in the Ventilation of Metal Mines: Bureau of Mines Bull. 385, 1935, p. 72.

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TABLE 2. - Ventilation quantities and percentages of methane (partial tabulation)

Place	Station No.	Quantity, c.f.m.	CH_4, percent
Bottom of downcast shaft	-	11,000	-
East side pit bottom	1	48,200	-
West side pit bottom	49	61,900	-
East side pit bottom, level beyond top of east dips	2	40,200	-
Split to Lock and Key district	3	24,900	-
On Lock and Key main intake near entrance to return level	13	17,500	-
100 yards of first place in Lock and Key district	18	5,300	-
First working place in Lock and Key	19	3,000	0.67
Face of headings in first panel	Near 21	4,000	0.94
Last place in first panel	22	4,000	1.75
First place in second panel	27	3,000	0.79
Last place in second panel	Near 29	5,600	1.09
First place in third panel	Near 34	10,800	0.71
Face of Wally's heading in Wally's district.	Near 37	6,800	1.78
Last working place in Lock and Key district.	Near 37	6,800	2.29
Return heading near faces in Wally's heading	Near 39	6,800	2.29
Return of Lock and Key district on dip going towards small pit	Near 43	22,200	1.29
Return heading off Indian level going to level at bottom of main roof-up	Near 48	28,200	1.03

TABLE 3. - Cross-sectional areas of airways (partial tabulation)

Section or station No.	Cross-sectional areas in square feet, as measured at intervals along section of airway	Remarks
1	54, 70	Starting on east side of down cast shaft.
2	59.1, 49.6, 47	
3	56, 57, 42.6	Near entrance to new lower vein split.
4	40, 35.9, 40	Up along Lock and Key main heading.
5	42, 35.8, 33.2	
6	59, 35.4, 41.3	
7	52.3, 31.8, 43.8	
8	32.8, 48, 41.7	
9	39; 50.37, 65.8	Continuing up main Lock and Key heading.
10	50, 35.6, 99.7	
11	27.5, 35, 37.6	
12	34.3, 33.6, 68.4	
13	48, 45, 86.0	Station near first level to left near haulage engine.

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TABLE 3. - Cross-sectional areas of airways (partial tabulation) (Cont'd.)

Section or station No.	Cross-sectional areas in square feet, as measured at intervals along section of airway	Remarks
14.....	32.4, 33, 26.0	
15.....	31.6, 30, 34.5	Along level beyond present working heading.
16.....	44.6, 43.8, 36.4	
17.....	25, 48, 52	
18.....	45, 34, 22	
19.....	36, 27.6, 34.7	
20.....	17, 23.4, 42.7	Working places in first panel in Lock and Key district.
21.....	20.5, 22.8, 38	do.
22.....	26.9, 28, 25.5	do.
23.....	28.5, 27, 33	Airway leading from first panel out to main heading.

With reference to figure 1, apparent discrepancies in rates of flow from point to point are accounted for by leakages in or out of the airways, which could not be detailed on a small map.

Interpretive Discussion

An interpretive discussion accompanies the statistical and graphical report that the committee submits, as shown by the following excerpt from the report on the ventilation of this mine:

> The quantity of air is well maintained up to Station 13. Just beyond this point there is a door at the entrance to the level to the left side, and about 7,000 cfm of air pass through and around the door and along the level to the return airway. If this leakage was reduced to about 1,000 cfm a much (greater) quantity of air would be available for circulation round the faces in the Lock and Key District. There is also about 2,000 cfm leakage through another door thirty yards above on the Main Heading, but this leakage is not wasted as it supplements the quantity of air coming from the workings of the first panel of the district.
>
> The first panel of 13 places, No. 18 to 23 on plan (fig. 1) is ventilated by a quantity of 4,000 cfm. There is plenty of room for the air to travel to all parts and the CH_4 content in the general body is kept below 1 per cent, except in the last working places, between No. 21 and 22 on plan, where due to lack of proper coursing of the air, the CH_4 concentration recorded was 1.75 per cent. This could easily be remedied.

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The main heading of the first panel was very nearly connecting out to the lowest stall in the second panel (No. 27 on plan), and when this takes place it will reduce the length of the air circuit by 500 yards.

The second panel of 12 places, Nos. 27 to 29 on plan, was well-ventilated. One very good feature in these first two panels of workings is the reduction of the Little Brass Seam exposure in the roof. In the past this seam gave off heavy blowers of gas.

The airway from the Main heading to the parallel heading, between No. 29 and 30 on plan, is rough and small in parts. The size of the parallel heading is good for about 80 yards, but from there down to the entrance to the road leading to the next working road the heading gradually gets worse, both in condition and in size. This applies to a length of about 50 yards.

It will be seen that the CH_4 given off in the third panel and in the three last working places, Nos. 34 to 37 on plan, raises the percentage of methane in the general body of the air from 0.71 to 2.29 in a quantity of 8,000 cfm. If the quantity in circulation in these places was increased to 12,000 cfm, the percentage of gas would be reduced to around 1.5 percent. This increase in ventilation quantity could be achieved if proper attention is given to the leakages around the doors on the Main Heading (No. 13 on plan), already referred to.

Apart from the right-angle bends, the airway from the faces towards the small pit (No. 44 on plan) down to the heading off Indian Level is in good condition. The pit itself is small, with sharp turns at the top and bottom, and three thick lines across the airway at this part show that three-tenths of an inch of water gauge is used in this short length.

The airway from here down to Indian Level (No. 46 on plan) is satisfactory. The level itself is good for about 80 yards outby the bottom of the heading, but for the next 100 yards, between Nos. 46 and 47 on plan, out to the bottom of the heading leading to the bottom of the Main Roof-Up the condition was poor. This is shown clearly by the number of black lines across the Level in this length. Along the heading to Station 48, which is the end of this circuit, the airway is very much better, although it should be much larger for the quantity of air passing, namely, over 28,000 cfm.

Detailed discussion of this type is submitted for the entire mine, with a rounded description of general ventilation arrangements that covers the characteristics and location of fans and includes a statement of their performances. The entire presentation is summarized, and conclusions are drawn for use of the operating staff in its efforts to increase the effectiveness of the ventilation.

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Environmental Surveys

Full environmental surveys are made periodically at each colliery in addition to the ventilation surveys. Environmental surveys cover dry-bulb temperature, wet-bulb temperature, relative humidity, cooling power (by dry) kata), and effective temperature. Air samples and dust samples are taken at appropriate sections. Instrumentation for these surveys includes konimeters and thermoprecipitators for dust sampling, kata thermometers and sling psychrometers. Survey data and criteria derived from them are tabulated in detailed reports, which the committee submits to the management of the colliery in question. Cooling power and effective temperature are shown graphically to signalize local improvements or impairments in conditions from survey to survey. Results of dust sampling are included in the tabulations with notations as to what productive equipment is used in each place and the working arrangements. Particular attention is given to methods used for dust suppression.

Environmental standards are maintained by the committee to cover work in coal or rock. Any defective condition revealed by the environmental surveys is called to the attention of the management of the colliery by the committee in submitting its report. The management is expected to study the detailed report as a help in improving conditions on its own initiative, in addition to acting on recommendations of committee engineers, one of whom checks on observance of recommendations a few weeks after the report has been submitted and makes additional recommendations as indicated by his reexamination. A stated objective of the program is expressed as a slogan; "Treat all dust as gas."

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